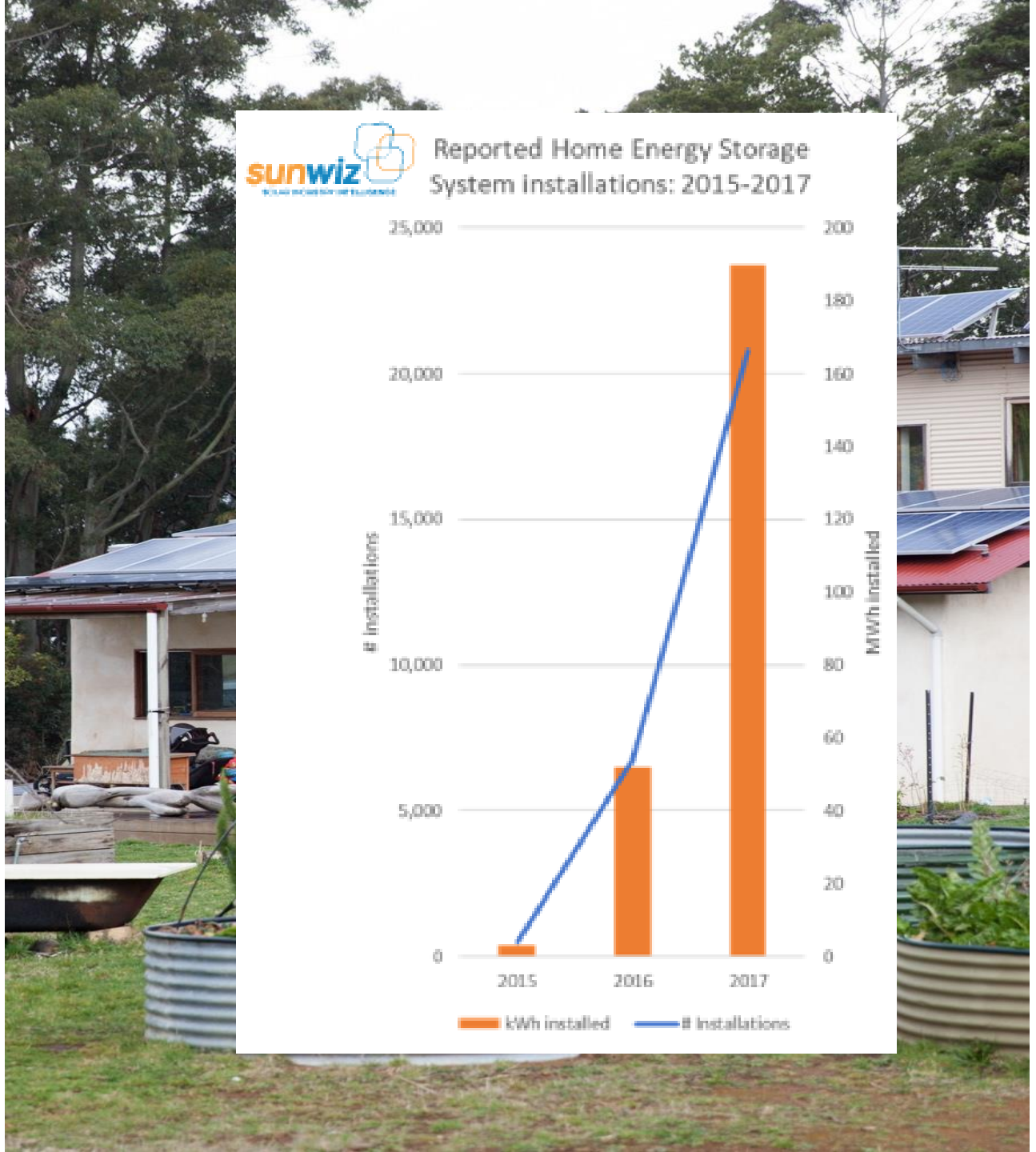
# Solar Plus Energy Storage – Why not go off-grid?

**Trevor Berrill**
Sustainable Energy Systems Consultant
www.trevolution.com.au


Thanks to Glen Morris for some Slides

# Solar PV or SHW – 3 mill. homes across Aust.

- Most homes have **enough roof area** to produce all the energy they need.
- If we **improve efficiency of energy use** first > reduced PV system size and cost.
- **172,000 PV systems** 2017
- **20,000** had Battery Systems installed



# Going Off-Grid?

## Benefits

- Energy independence – no utility bills?
- No transmission lines

## Things to Consider

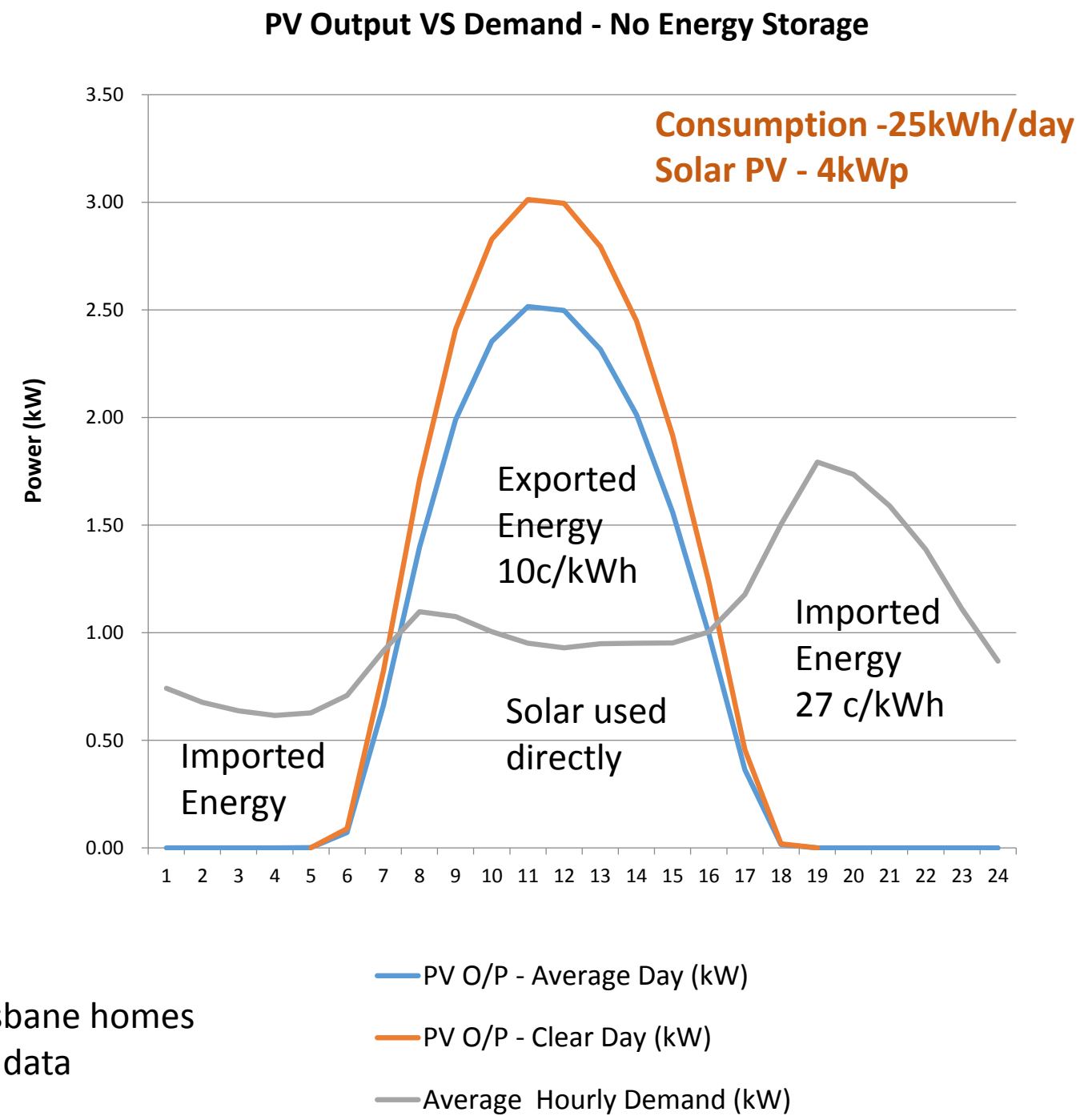
Requires self-management of energy use

Increased cost – must design for worst conditions (poor solar + high demand)

- ➢ Oversized PV array (2.5x) and Battery (5 days of storage)
- ➢ Wasted PV Energy – no export
- ➢ Higher Embodied Energy
- ➢ May required back-up generator

# Grid PV – No Battery

- **Supply** doesn't always match **demand**
- **Exported energy** sold at very low Feed-in Tariff rates (10 - 16c/kWh)
- **Imported energy** bought at 25 - 30c/kWh
- **Fixed Supply Charge - $360 to 470pa**.




Source of Data:
Energex Load Profile Data aggregated over 400 Brisbane homes
Solar Irradiance: Ausolrad software based on BOM data

# Why Storage - Drivers & Factors to Consider

- Save money – self-consume your solar
- Stabilising electricity costs
- More control over energy supply
- Environmental Concerns & support RE
- Back-up in power outages
- Sell clean energy to grid
- I just want one – techno enthusiast

- Complexity – configurations and battery/inverter types/tariffs
- Financial Value – New or Retrofit
- Quality / Size of Equipment
- Management

# Community Benefits of Energy Storage?

## Community Benefits

- Environmental – fuller use of solar PV in areas with export constraints

- Electricity Network Benefits
  - ➢ peak demand management
  - ➢ reduced or deferred infrastructure costs
  - ➢ reduces transmission energy losses

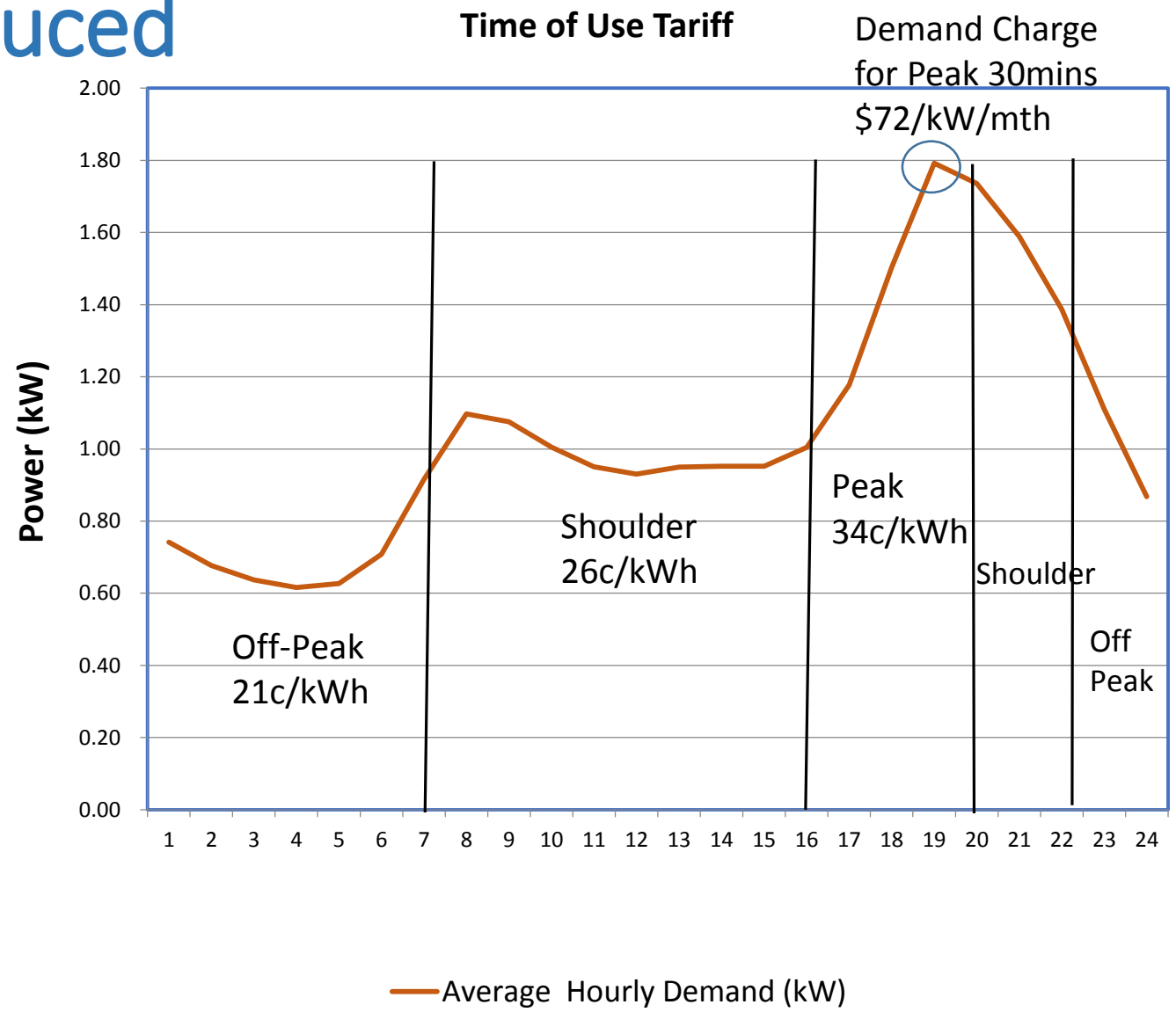
# New Tariffs being introduced

**Variable Costs**

- Currently - Flat Rate Tariff – 25 - 30c/kWh
- **Time of Use (TOU) Tariff Eg. Ergon**
  1. Peak 34c/kWh,
  2. Shoulder 26c/kWh
  3. Off-peak – 21c/kWh
- **Demand Tariff - $72/kW/month**

**Fixed Costs**

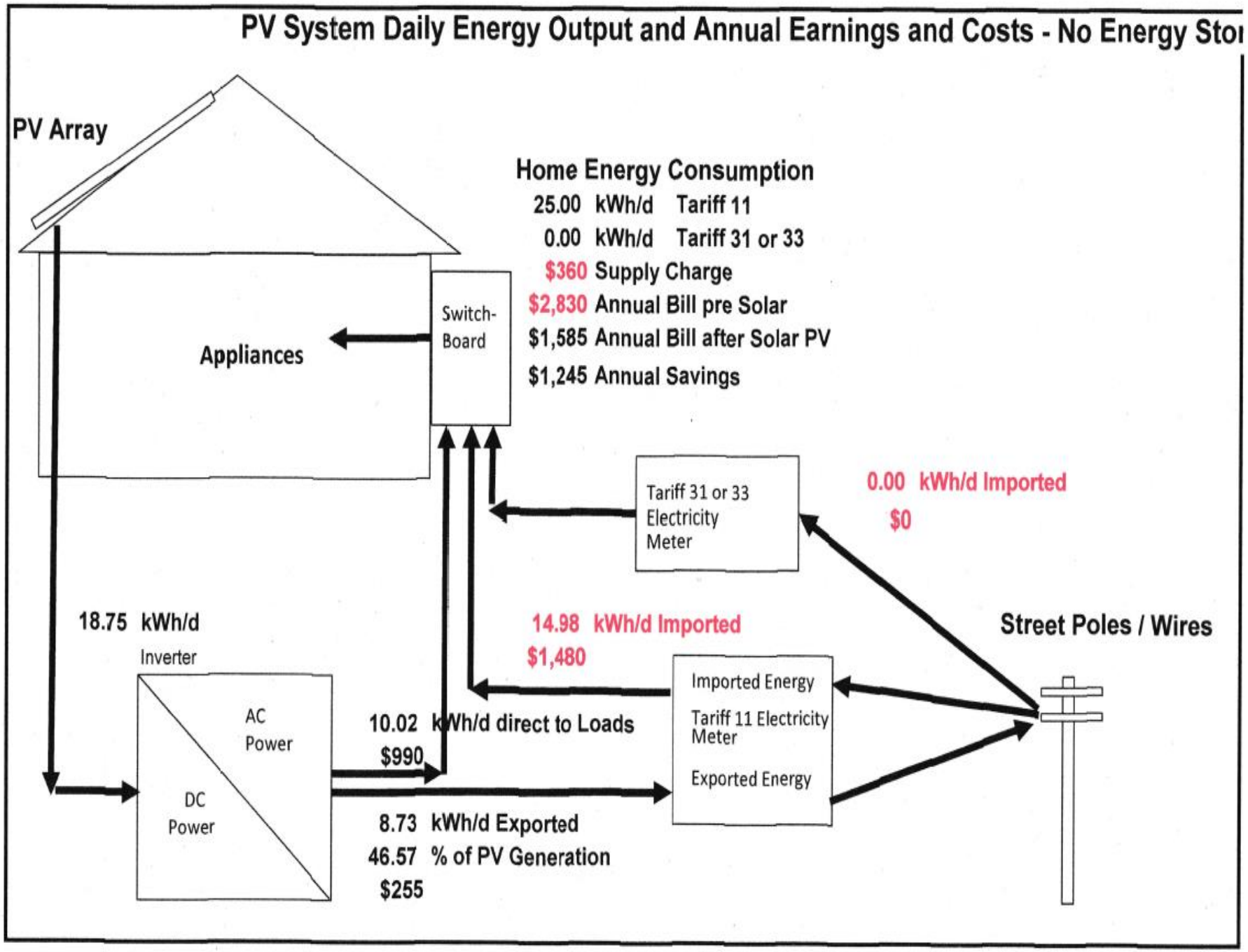
- Supply Charge  E.g 128c/kWh or $470/yr




NB: Load profile curve from Energex Data

# PV – No Battery
# PV Size - 4kW
# Usage 25kWh/day

- Net feed-in tariff is low?
- Export 47% of PV Energy
- Export Earnings $255 /yr
- Self-consumption $990/yr
- Simple Payback 5yrs



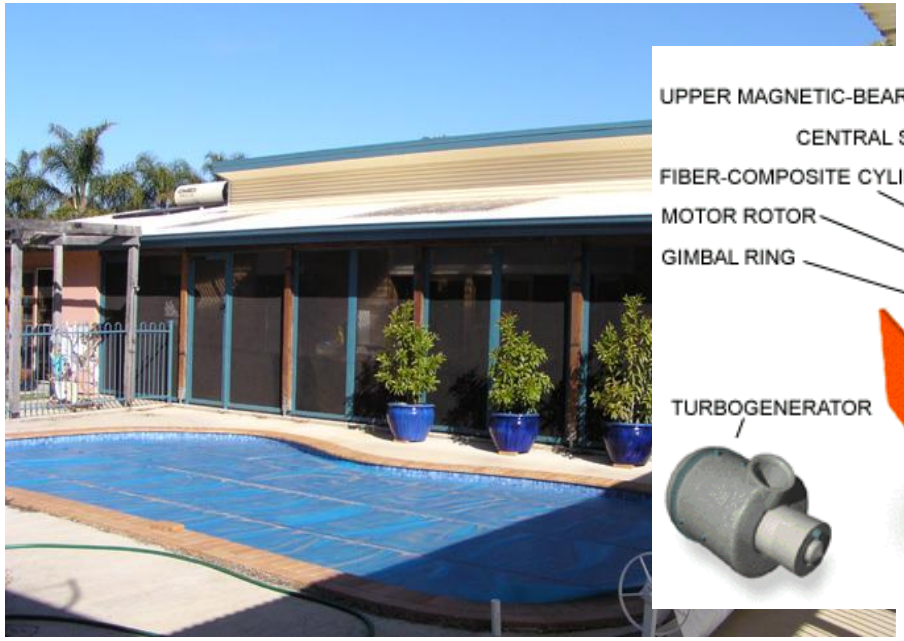
# Things to do before adding Batteries

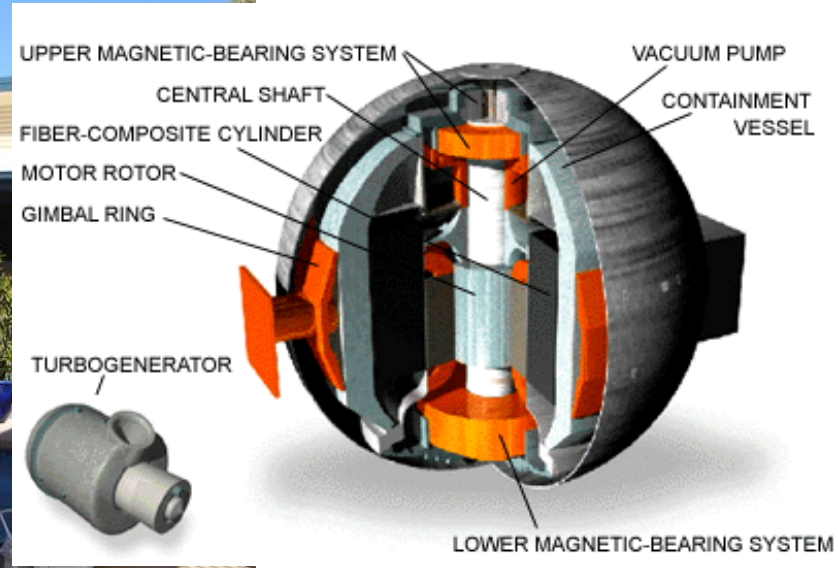
- **Shop for best Elect Prices**
- https://www.energymadeeasy.gov.au/offer-search
- **Reduce Consumption**
  - Efficient Appliances – E.g. Heat Pumps, LEDs, Pool VSD
  - Swap fuel source – solar thermal
  - Manage better – sensors / timers to turn off
  - Improve building envelop – insulation / shading control

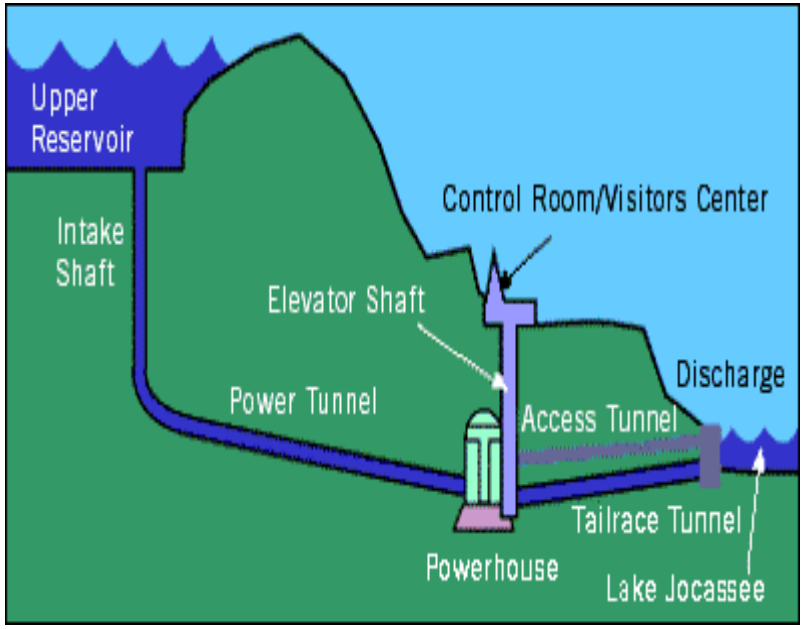
- **Shift Demand**
  - Solar Bonus FIT – use at night off-peak
  - Standard FIT – shift loads to day-time – Hot Water, Air Con., Pool, Dish Washer, Clothes Washer, Cooking
- **Add more PV**, particularly facing E & W

# How can we store energy?

- **Medium and Low Heat Temp. & Coolth** (Hot Water/Pool Heating/Space Conditioning)
- **Chemical** – Batteries (Starting/Appliances/Off-grid homes)
- **Hydro Electric** – mass x gravity x height (Split-yard Creek, Wivenhoe)
- **Flywheel** – mass x velocity$^2$

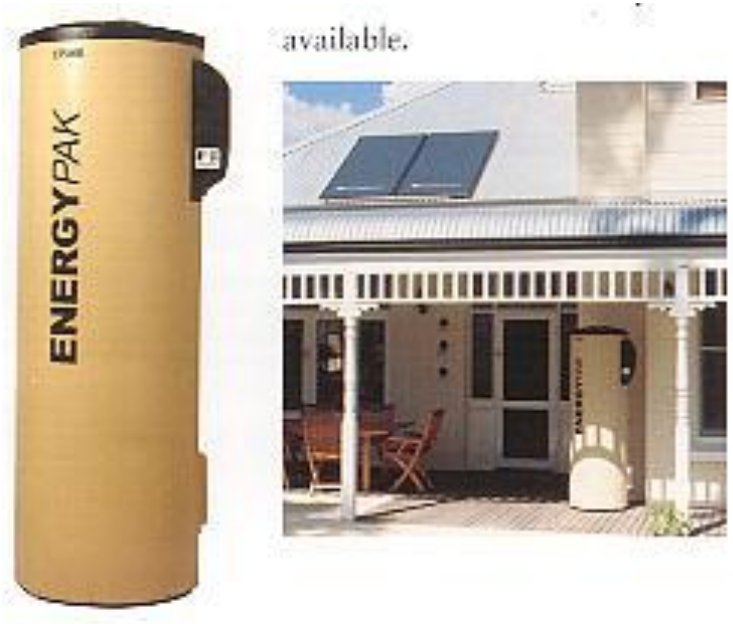


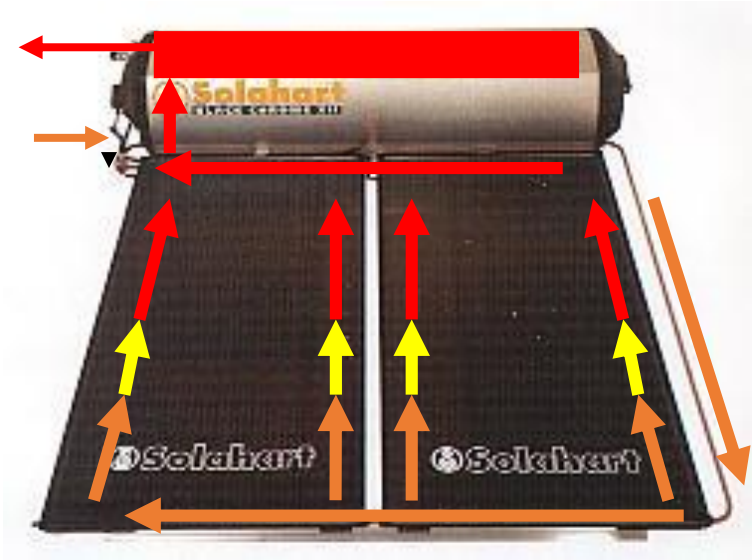



# Flat Plate Close Coupled or Split (pumped) Systems

**Split System**: Tank on ground. Water pumped to collectors on roof.




**Close-coupled System**: Tank on roof above collectors. No pump.

- Cheapest for new homes
- Selective Surface Collectors for Higher Solar Faction up to 95%
- About same cost as electric heat pump hot water systems.

## Evacuated Tube

# Solar Hot Water from Solar PV

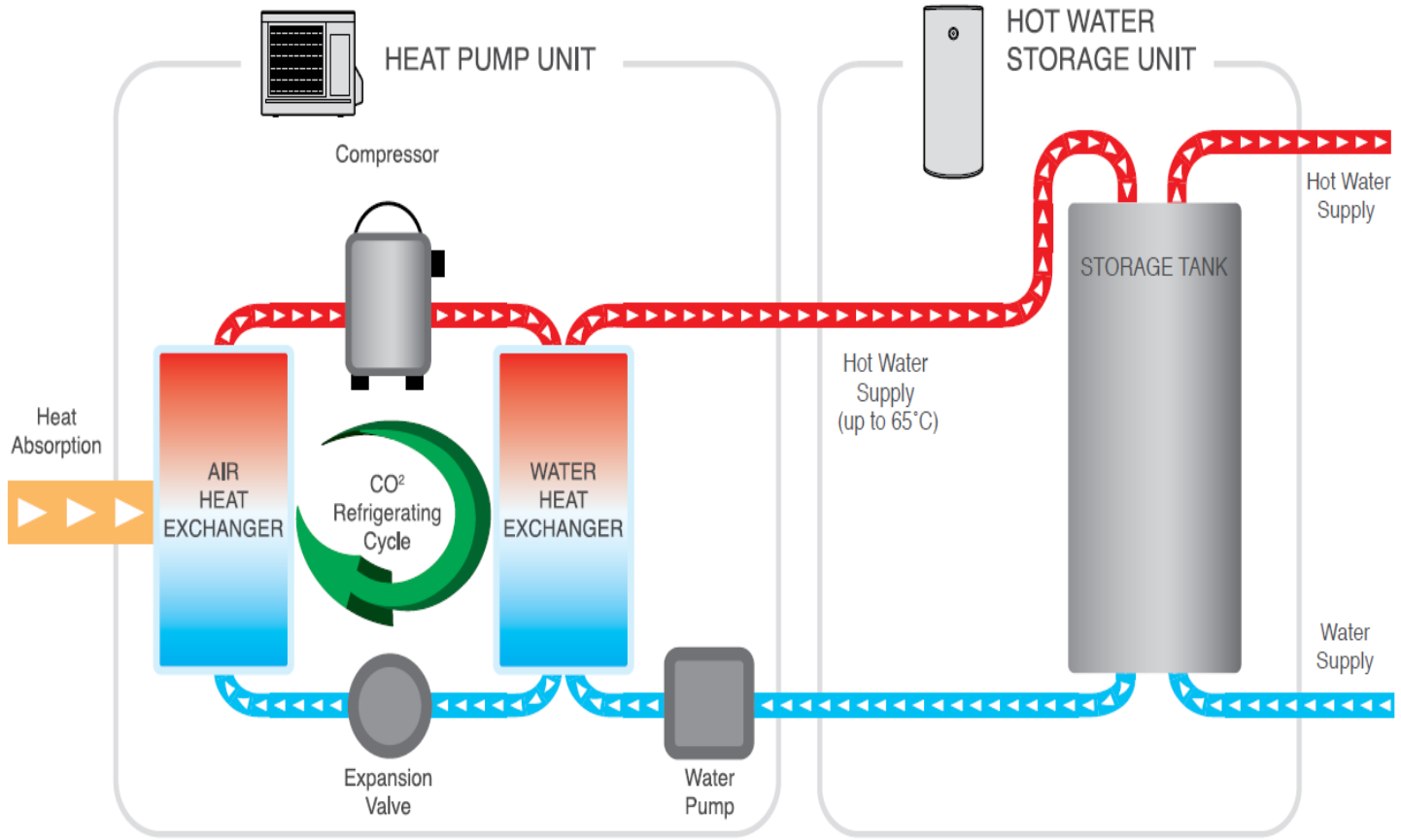
# Heating & Cooling

## Heating

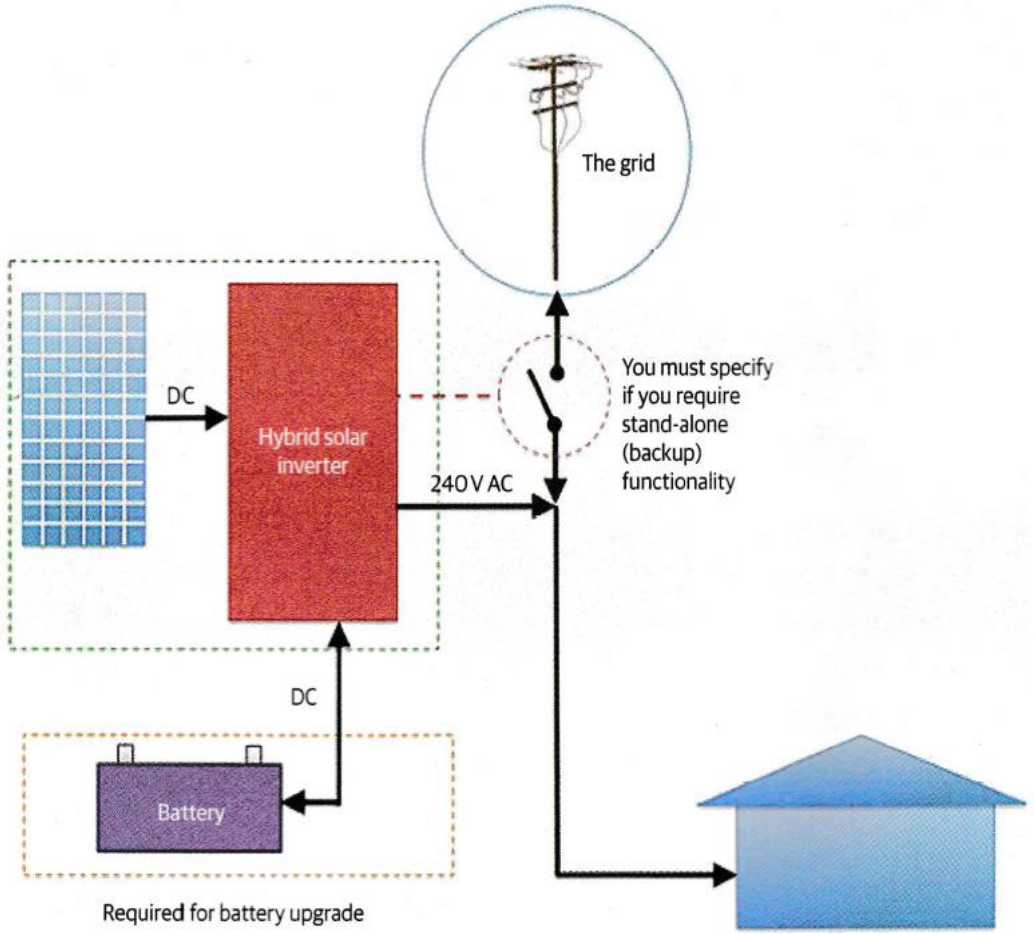
- **Resistance Heater** – 1.5 to 3kW PV array required
- **Heat pump** – reduces size of PV array by factor of 4 or more > 0.3 to 0.7kW

## Cooling

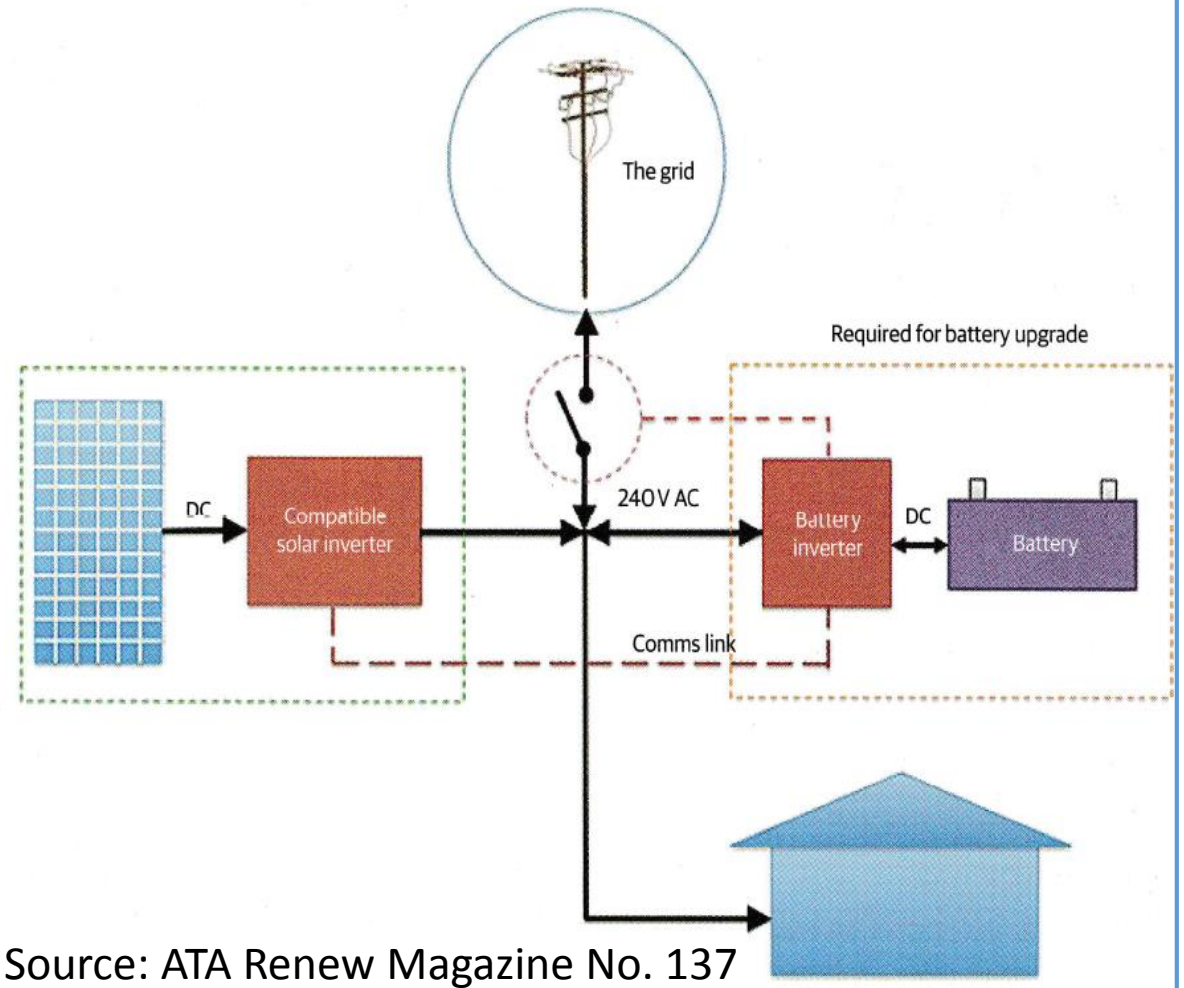
- Chilled Water
- All systems must have well insulated tanks



# System Configurations – DC & AC Coupling




↑ Figure 1: DC coupling configuration. DC solar is fed through the hybrid inverter for charging of the battery or conversion to AC for use by the household. The hybrid inverter also controls use of the DC electricity from the battery. In a fairly recent development, an alternative approach to DC coupling involves using a standard grid-interactive solar inverter with a DC to DC converter.



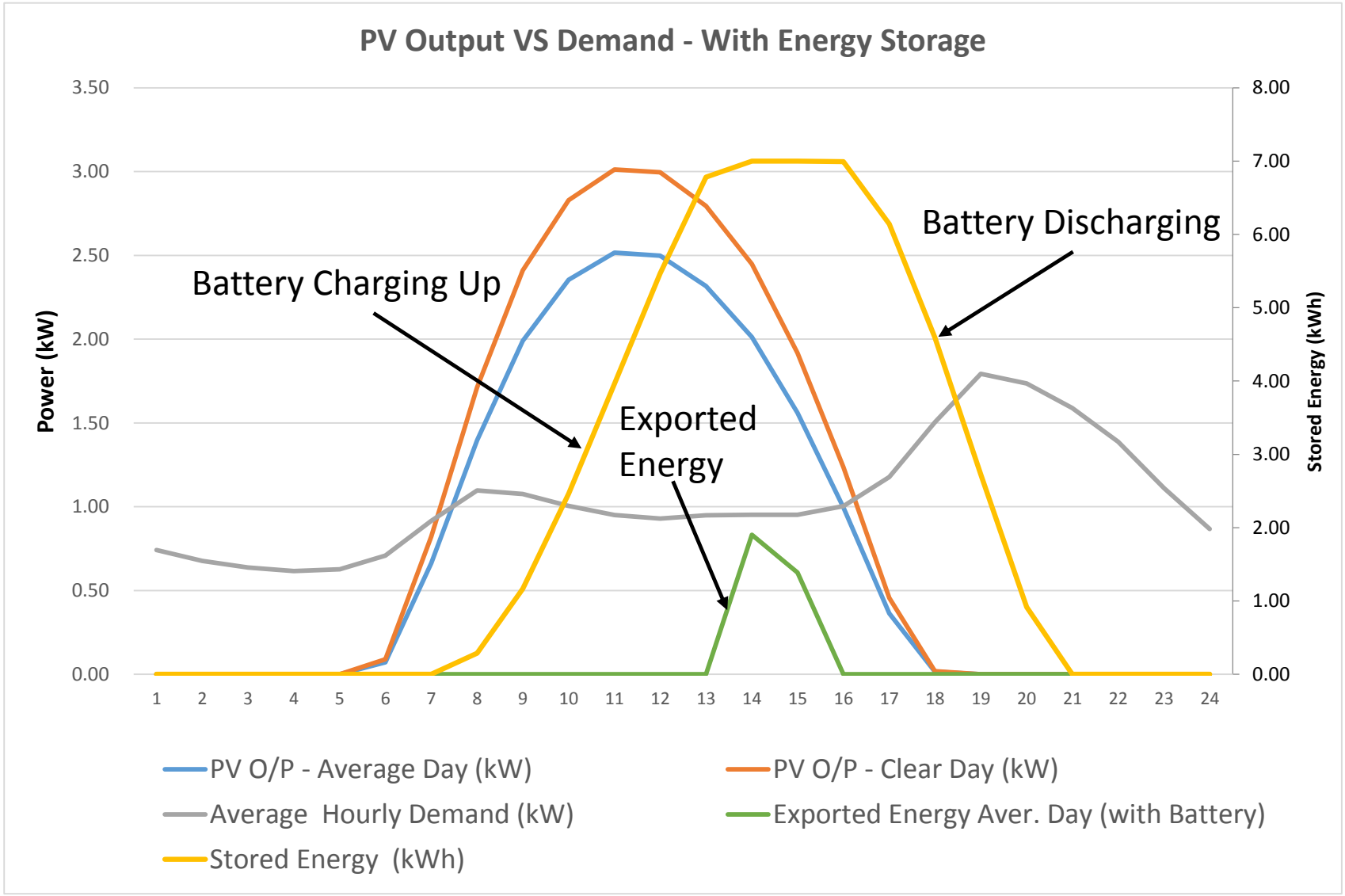

Source: ATA Renew Magazine No. 137

↑ Figure 2: AC coupling configuration. DC solar is converted to AC by the solar inverter for use in the household or fed through the battery-dedicated inverter-charger for charging of the batteries. A communications link is needed between the solar inverter and the inverter-charger to allow the PV production to be controlled when the system is running in backup mode.

# Battery Charging for Night Consumption

- Store exported energy for night use
- Save on high electricity rates in peak periods
- Use electricity from grid at low rate periods

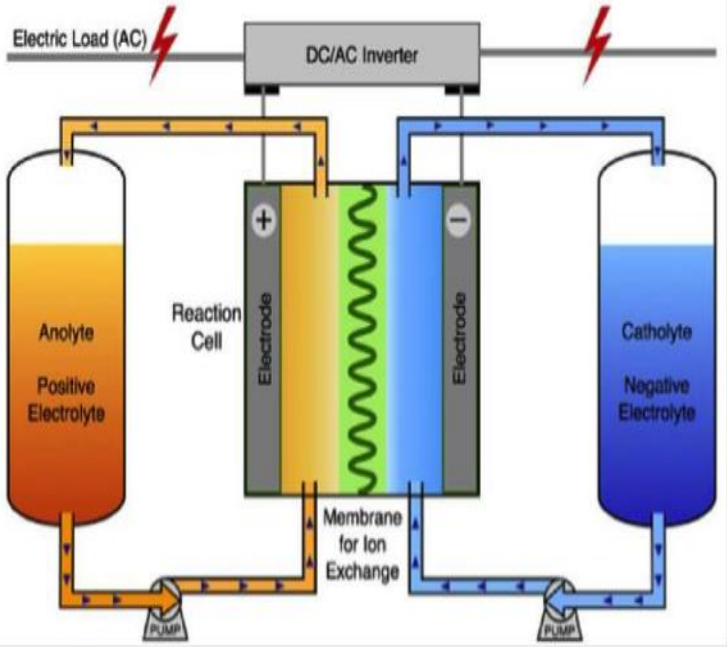
NB. Analysis for Brisbane



# Battery Types & Chemistries

- Lead Acid – Gel or AGM (Sealed)
- Modified Lead Acid – C Plate Ecoult
- **Lithium – LG, Tesla, Sonnen, Fronius**
- Flow Batteries - Redflow
- Salt Batteries – Aquion
- Nickel Chloride (High Temp.)

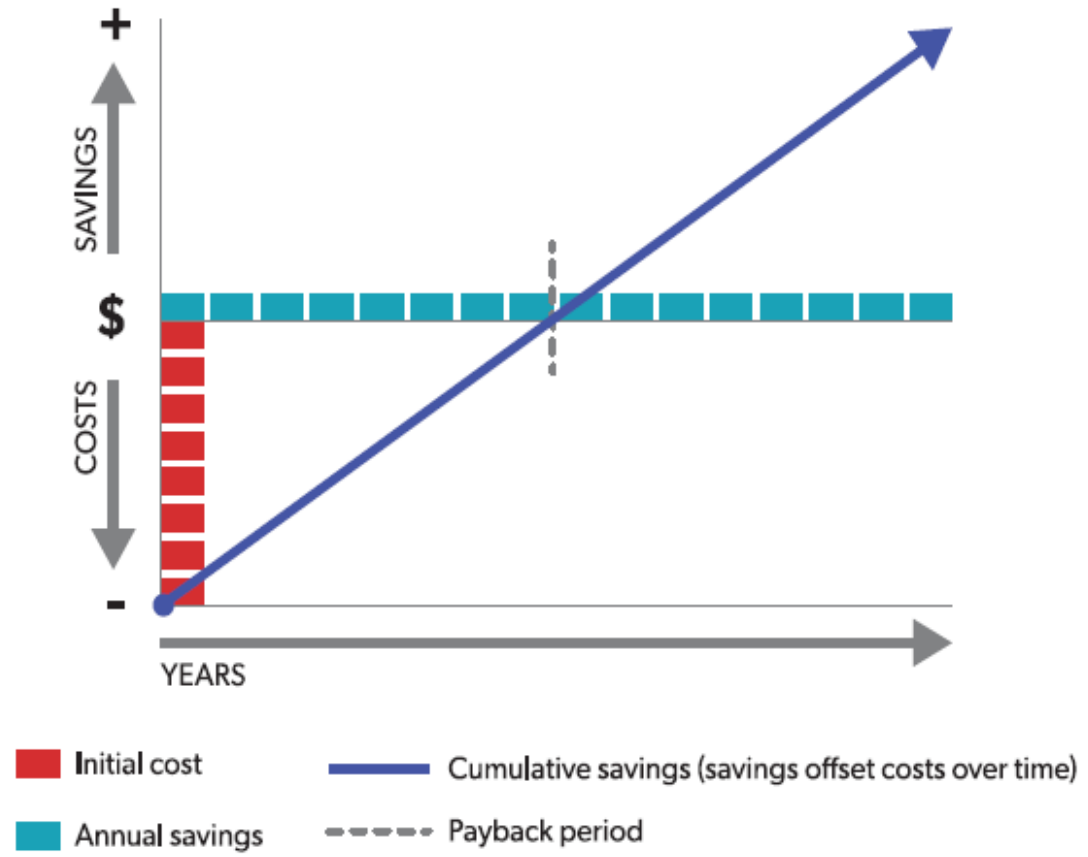





# Calculating Value & Payback Time – for Battery Only

- What is the Value of Battery
  - Savings on current bill
  - Insurance against Future electricity price rises?
  - Reliability – no power outages
  - Environmental
  - Sell at peak periods

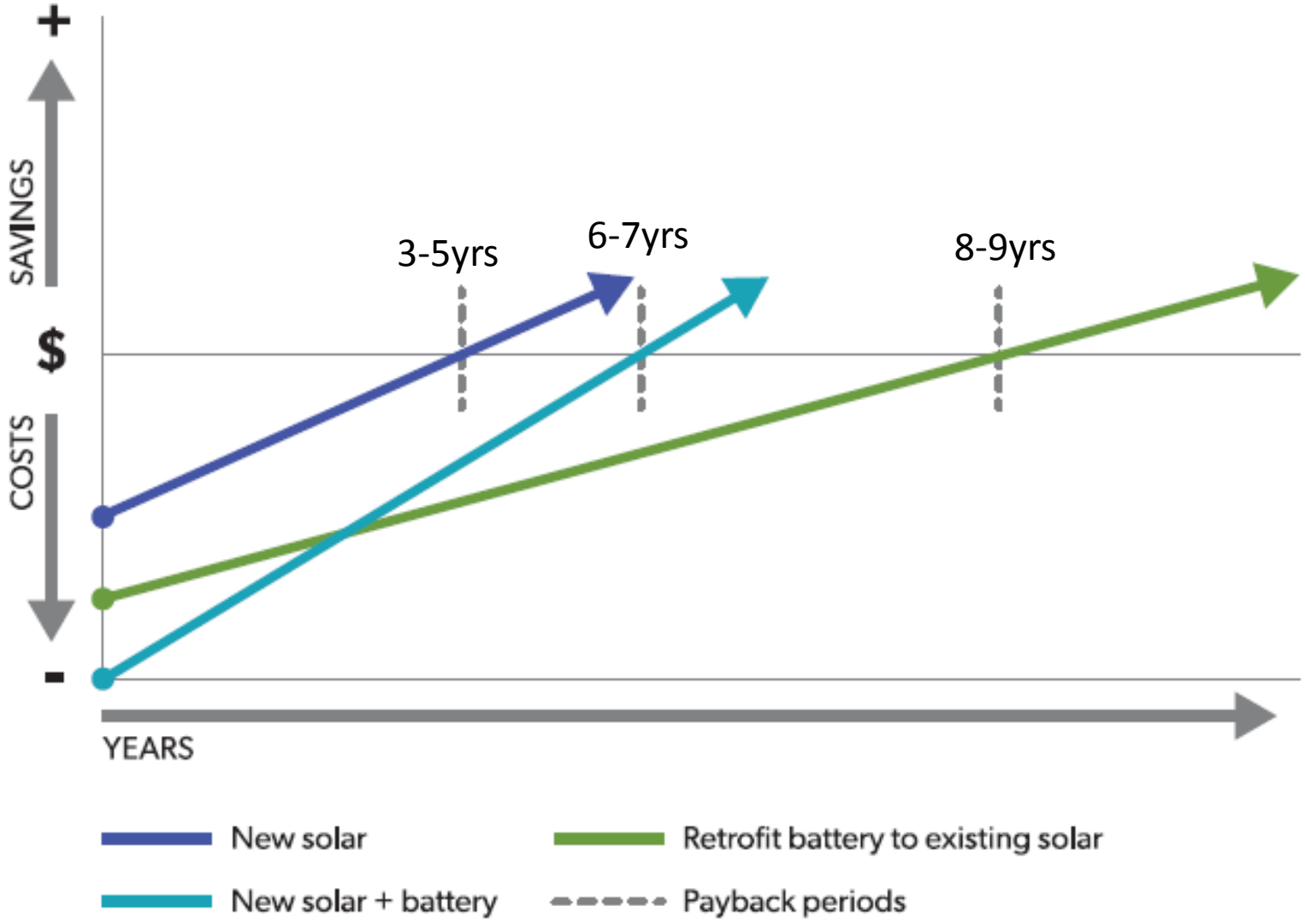
**Understanding the payback period (Figure 10)**



# Typical Payback Times

- Best for Larger Users
- Small Battery Cap. = shorter payback
- Use Modular Battery/Inverter Systems

**Typical payback periods in 2017 for different battery system options (Figure 12)**



# Economics

Payback Time affected by:

- Electricity Tariff Rate (c/kWh)
- Tariff Structure – Flat or Time of Use
- Feed-in Tariff Rate (c/kWh)
- Battery / Inverter / Charger Costs / Life

Home Consumption – 25 kWh/day
PV Array – 4kW
Battery Capacity – 7kWh (usable)
Battery Cost – $826/kWh

**Results – Simple Payback Time**
No Battery - 5 to 6 years
With Battery – 7 to 8 years
Capital Cost – Double for Battery
Extra Savings - $500 per year

NB: Analysis using Ergon Tariffs

| Options Analysis - Summary all Options | Flat Rate - No Battery | TOU Rate - No Battery | Flat Rate - with Battery | TOU Rate - with Battery |
|---|---|---|---|---|
| **Additional PV Size (kW)** | **4.00** | **4.00** | **4.00** | **4.00** |
| Total PV Array Output (kWh/day) | 18.8 | 18.8 | 18.8 | 18.8 |
| Percentage PV Exported (%) | 46.6 | 46.6 | 7.7 | 7.7 |
| Annual Bill before Solar ($) | $2,830 | $2,720 | $2,830 | $2,720 |
| Annual Bill after Solar($) | $1,585 | $1,664 | $1,134 | $1,099 |
| **Annual Savings ($)** | **$1,245** | **$1,056** | **$1,696** | **$1,621** |
| **Simple Payback Time (yrs)** | **5.3** | **6.3** | **7.3** | **7.7** |
| Return on Investment (%) | 18.7 | 15.9 | 13.6 | 13.0 |
| Capital Cost pre STCs ($) | $9,800 | $9,800 | $15,582 | $15,582 |
| No. of STCs over 15 yrs | 83 | 83 | 83 | 83 |
| Value of STCs ($) | $3,154 | $3,154 | $3,154 | $3,154 |
| **Installed Capital Cost after STCs ($)** | **$6,646.00** | **$6,646** | **$12,428** | **$12,428** |
| **Installed Cost per Watt after STCs ($/W)** | **1.66** | **1.66** | **3.11** | **3.11** |

# Adding to existing solar power system?

- Government rules that might apply to adding batteries
- Government Incentives to add batteries
- Add new system in parallel to store energy
- Innovative battery retrofit solutions
- Innovative software to monitor and optimize energy use and costs

# Summary

- The Solar Revolution is here and is providing cheaper power
- The Battery Revolution is underway and already affordable for some
- Batteries increase the value of solar energy - dispatchable
- The Next Revolution unfolding is the Electric Car